IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of		)
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	Young Jun HWANG et al.	)
		)
Serial No.:	Unassigned	) Art Unit
		) Unassigned
Filed:	Herewith	)
		)
U.S. National Stage		)
of PCT Serial No.:	PCT/KR2004/000892	)
		)
Int'l Filing Date:	19 April 2004	)
		)
For:	FUEL CELL	)
		)
Customer No.:	029913	)

SUBSTITUTE SPECIFICATION IN MARKED UP FORM UNDER 37 C.F.R. §1.125

Commissioner of Patents
Alexandria, Virginia 22313

Dear Sir:

The following substitute specification in marked up form is hereby submitted with the above-referenced application. A clean version is also filed herewith. This substitute specification includes no new matter.

Dated this 16th day of October, 2006.

Respectfully submitted,

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FUEL CELL

BACKGROUND

1. The Field of the Invention

[0001] The present invention relates to fuel cells, and more particularly, to a fuel cell which can enhance an electricity generating performance.

2. The Relevant Technology

[0002] ~~The~~ A fuel cell is an energy transformation device for the direct transformation of ~~a~~ chemical energy of a fuel into an electrical energy by means of a chemical reaction. Different from a ~~general~~ typical battery, ~~the~~ a fuel cell can generate electricity continuously without recharging as ~~far~~ long as fuel is fed into it ~~without recharging~~. Recently, interest ~~is focused o~~in the fuel cell has grown owing to ~~the~~ its high energy efficiency ~~,~~ and ~~the~~ environmental friendly nature.

[0003] In general, ~~the~~ a fuel cell is provided with two electrodes, i.e., an anode and a cathode arranged on opposite sides of an electrolyte. ~~In general~~Typically, there ~~are~~ is also an anode side separator on an outer side of the anode having a fuel passage and supporting the anode, and a cathode side separator on an outer side of the cathode having an air passage and supporting the cathode. An electro-chemical reaction of ~~the hydrogen,~~ the fuel, takes place at the anode, and an electro-chemical reaction of ~~the~~ oxygen, an oxidizer, takes place at the cathode~~, and~~. These electro-chemical reactions cause electric energy to be ~~is~~ generated ~~owing~~ due to the migration of electrons taking~~en~~ place ~~in this time~~during the reactions.

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[0004] ~~The~~ Typical fuel cells may use a variety of fuels, such as LNG, LPG, methanol, gasoline, and the like. In general, the fuel is refined as hydrogen by passing it through a desulfurization process, a reforming reaction, and a hydrogen refining process at a fuel reformer, and is used in a form of hydrogen gas. In some embodiments, ~~A~~ fuel of a water solution state, for an example~~,~~ a solid state BH_4^- ~~is~~ dissolved into a water solution state, is used as the fuel (Boro Hydride Fuel Cell). The Boro Hydride Fuel Cell (BFC) can dispense with the fuel reformer as the fuel of a water solution state is fed to the anode directly, and the reforming reaction takes place at the anode without the fuel reformer, ~~enabling to~~thus simplifying ~~a~~ the fuel cell system.

[0005] Typical fuel cells may also use a variety ~~In the meantime, according to kinds of the~~of electrolytes. For example,~~,~~ there are phosphoric fuel cells, molten carbonate fuel cells, alkaline fuel cells, solid oxide fuel cells, and polymer membrane fuel cells, and the like.

~~**[0006]**A related art fuel cell system will be described with reference to FIG. 1.~~

~~[0007]~~[0006] Referring to FIG. 1, a conventional fuel cell is illustrated. As illustrated in FIG 1, fuel is fed from a fuel tank 5 to a fuel cell 1 by a fuel pump 3, and air is fed to the fuel cell 1 by an air pump 7. The fuel cell 1 ~~is a~~may be a unit cell or a stack of ~~the~~ two or more unit cells.

~~**[0008]**An example of a related art fuel cell will be described with reference to FIGS. 2 to 4. Each of FIGS. 2 to 4 illustrates a unit fuel cell.~~Referring now to FIGS 2 through 4, a specific example of another conventional fuel cell will be described. Note that each of the FIGS 2 to 4 illustrate a unit fuel cell. As illustrated in FIG 2

~~[0009]~~[0007] t~~T~~here ~~are~~ is an anode 30 and a cathode 20 at opposite sides of an electrolyte 10. There are also separators 40 and 50 at an outer sides of the anode 30 and

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the cathode 20, respectively. The anode 30 and the cathode 20 are porous and in general include Pt catalyst.

[0010]~~[0008]~~ ~~Thus~~As mentioned, there ~~are~~ is an anode side separator 50 at an outer side of the anode 30, and a cathode side separator 40 at an outer side of the cathode 20. As illustrated in FIGS 3 and 4, t~~T~~he separators 40 and 50 support the anode 30 and the cathode 20 respectively, and have passages 46, and 56 formed in general between barriers 44, and 54. Note that t~~T~~here can be a variety of passage forms. The separators 40, and 50 serve to separate individual unit cells when unit cells are stacked. In ~~the meantime~~addition, there can be separate electricity collecting plates at an outer sides of the separators 40, and 50, respectively.

[0011]~~[0009]~~ ~~In general~~Typically, the electrolyte is an ion exchange membrane of a polymer material. A typical commercially available electrolyte membrane is Nafion membrane ~~of~~ from Du Pont, ~~and~~ which serves as a transfer body of hydrogen ions~~, and,~~ while at the same time ~~with this,~~ prevent~~ings~~ the oxygen from coming into contact with the hydrogen. Also t~~T~~he anode 30 and the cathode 20 are supporting bodies having a catalyst attached thereto of~~, in general,~~ porous carbon resin or carbon cloth or other suitable materials. Further, t~~T~~he separators 40, and 50 are formed of~~, in general,~~ dense carbon material, or Ni/SUS material or other suitable materials.

[0011]The action of the fuel cell will now be described as follows.

[0013]~~[0010]~~ The fuel and air fed to the fuel cell flow through the anode 30 and the cathode 20, and make the following chemical reaction:~~.~~

~~[0014]~~Anode : $BH_4^- + 8OH^- \rightarrow BO_2^- + 6H_2O + 8e^-$ $E_0 = -1.24V$

~~[0015]~~Cathode: $2O_2 + 4H_2O + 8e^- \rightarrow 8OH^-$ $E_0 = 0.4V$

~~[0016]~~Total : $BH_4^- + 2O_2 \rightarrow 2H_2O + BO_2^-$ $E_0 = 1.62V$.

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~~[0017]~~[0011] ~~In the meantime~~Typically, in order to make the BH_4^- stable solution, ~~in general~~ a certain amount of Na is mixed, to cause a side reaction to generate hydrogen gas at the anode 30. That is, a reaction of $2H_2O + NaBH_4 \rightarrow NaBO_2 + 4H_2$ takes place at the anode 30.

~~[0018]~~[0012] ~~In the meantime~~Accordingly, improvement of ~~an~~ the electric generating capacity~~,~~ and performance of the fuel cell ~~have been required~~are desirable while ~~a~~ the size of the fuel cell is kept as it is. ~~Because~~This is because~~, despite of above advantages of the fuel cell,~~ as the size of ~~the~~ a fuel cell becomes ~~in general~~ larger for obtaining a desired electric generating capacity and performance, ~~that limits use of the fuel cell, and~~ it ~~is not~~becomes less convenient ~~in~~ to use.

~~[0019]~~[0013] Consequently, there have been many suggestions for improving the capacity and performance of ~~the~~ a fuel cell. For ~~an~~ example, Japanese Laid Open Patent No. H10-228913 ~~suggests~~ discloses the partial gold plating of electrodes and separators~~,~~ to reduce contact resistances between the electrodes and the separators, ~~to~~ thus improvinge the performance of the fuel cell. ~~In this instance, it is suggested that the separators are formed of metal, and the separators are formed of stainless steel for prevention of corrosion. However, though the various suggestions for improving the capacity and performance of the fuel cell have effects in some extent, the effects are not in general significant, to require fuel cells having a better electric generating performance.~~However, this approach has proven effective in only a limited number of circumstances, leaving a need in the art for a fuel cell having a better electric generating performance.

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BRIEF SUMMARY

~~An object of the present invention, designed to solve above problems, is~~Accordingly, the principles of the present invention are directed toward ~~to~~ provide~~ing~~ a fuel cell ~~which~~ that can improve ~~an~~ electric generating capacity and performance without increasing a size of the fuel cell.

[0014]

~~[0015]~~~~The object of the present invention can be achieved by providing a fuel cell including electrolyte, an anode and a cathode at opposite sides of the electrolyte, an anode side separator and a cathode side separator at outer sides of the anode and the cathode respectively, and a medium layer between the cathode and the cathode side separator for prevention of corrosion of the cathode side separator.~~

[0015] ~~In other aspect of the present invention, there is provided a fuel cell including electrolyte, an anode and a cathode at opposite sides of the electrolyte, an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, a porous supporting member between the cathode and the cathode side separator for supporting the cathode, and a supporting member medium layer between the cathode and the porous supporting member for prevention of corrosion of the porous supporting member.~~ One embodiment herein described discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, and a medium layer between the cathode and the cathode side separator configured to at least partially prevent corrosion of the cathode side separator.

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[0016] A further embodiment herein described also discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, a porous supporting member between the cathode and the cathode side separator configured to at least partially support the cathode; and a supporting member medium layer between the cathode and the porous supporting member configured to at least partially prevent corrosion of the porous supporting member.

~~**[0016]**In another aspect of the present invention, there is provided a fuel cell including electrolyte, an anode and a cathode at opposite sides of the electrolyte, an anode side separator and a cathode side separator at outer sides of the anode and the cathode respectively, and a medium layer between the anode and the anode side separator for prevention of corrosion of the anode side separator.~~

[0017] An additional embodiment herein described discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, and a medium layer between the anode and the anode side separator configured to at least partially prevent corrosion of the anode side separator.

~~**[0017]** Thus, an electric generating performance of the fuel cell can be improved, to enable improvement of an electric generating capacity without increasing a size of the fuel cell.~~

~~**[0025]**~~**[0018]** Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those

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having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings

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BRIEF DESCRIPTION OF THE DRAWINGS

~~[0026]~~**[0019]** To further clarify the above and other advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

~~[0027]~~**[0020]** FIG. 1 illustrates a block diagram of a ~~related~~ prior art fuel cell system;

~~[0028]~~**[0021]** FIG. 2 illustrates a disassembled perspective view of a ~~related~~ prior art fuel cell, schematically;

~~[0029]~~**[0022]** FIG. 3 illustrates a plan view of one example of the cathode side separator in FIG. 2, schematically;

~~[0030]~~**[0023]** FIG. 4 illustrates a section of FIG. 2;

~~[0031]~~**[0024]** FIG. 5 illustrates a circuitry expression of ~~the~~ a fuel cell ~~in FIG. 2~~;

~~[0032]~~**[0025]** FIG. 6 illustrates a graph of a voltage drop in the fuel cell of FIG 5;

~~[0033]~~**[0026]** FIG. 7 illustrates a section of a fuel cell in accordance with ~~a preferred~~ embodiments of the present invention, schematically;

~~[0034]~~**[0027]** FIG~~S~~. 8 ~~and 9~~ illustrates a graphs ~~each~~ showing a comparison of the electric generating capacity of the fuel cells of the present invention and the ~~related~~ prior art; ~~and~~

[0028] FIG. 9 illustrates another graph showing a comparison of the electric generating capacity of the fuel cells of the present invention and the prior art; and

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~~[0035]~~[0029] FIG. 10 illustrates a section of a fuel cell in accordance with ~~another preferred~~other embodiments of the present invention, schematically.

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DETAILED DESCRIPTION

~~[0031]~~[0030] Reference will now be made in detail to the ~~preferred~~ embodiments of the present invention disclosed herein, examples of which are illustrated in the accompanying drawings. In describing the embodiments disclosed herein, parts identical to the parts of the ~~related~~ prior art fuel cell will be given the same names and reference symbols, and a detailed description of ~~which~~ such elements will be omitted.

~~[0037]~~An example ~~preferred~~ embodiment of the fuel cell of the present invention will be first be described with reference to FIG. 7.

~~[0038]~~[0031] ~~Alike~~ As ~~the related art~~illustrated in FIG 7, ~~the~~ the example embodiment fuel cell ~~of the present invention~~ includes an electrolyte 10, an anode 30, a cathode 20, an anode side separator 50, and a cathode side separator 40. Of course, when the unit fuel cell of FIG 7 is staked in a stack of unit fuel cells, the cathode side separator 40 of the unit fuel cell will touch an anode side separator of a different unit cell. In like manner, the anode side separator 50 will touch a cathode side separator of a different unit cell. ~~Though the separator 40 or 50 has one side in contact with the anode 30, and the other side in contact with the cathode 20 at the same time in a stack type fuel cell having a plurality of unit cells stacked therein, for the sake of description, words of an anode side separator 50, and a cathode side separator 50 will be used in the following description.~~

[0032] ~~From study of the inventors, it is found out~~Typically the ~~that~~ prevention of corrosion of the side separators, particularly~~,~~ the cathode side separator 40, ~~is very important~~allows for improv~~in~~edg performance of the fuel cell. ~~Because~~For example, as shown in FIG. 5, when the fuel cell generates electricity, ions move from the anode → the electrolyte → the cathode, and electrons move from the anode (r2) → the anode side

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separator (r1) → the cathode side separator (r4) → the cathode (r3), wherein all the moving paths of the electrons ~~are~~ act as a kind of inner resistances. ~~By the way, as shown~~As shown in FIG. 6, if the inner resistance increases, ~~a~~ the performance of the fuel cell drops according to the I-V characteristics of the fuel cell.

[0033] ~~In the meantime, from the study of the inventors, it is found out that, during~~During operation of the fuel cell, ~~in general,~~ corrosion typically takes place at the cathode side separator 40, ~~and stain formed in this instance is a great~~which may be a cause of the increase of the inner resistance discussed above. ~~That is, the related art of the present invention fails to know that the~~However, conventional solutions to increasing fuel cell performance have failed to properly address prevention of corrosion of the side separator 40 ~~is~~ as one ~~of the most~~ important factors for improving the performance of the fuel cell. ~~Therefore~~For example, as described in the ~~related~~ prior art, Japanese Laid Open Patent No. H10-228913 suggests partial gold plating at contact surfaces of electrodes and side separators~~,~~ to reduce contact resistances between the electrodes and the side separators ~~simply,~~ and ~~to~~ the use of stainless steel as a material of the side separators for prevention of corrosion. However, ~~in general,~~ it is often difficult to avoid the corrosion effectively by using ~~the~~ a side separator of metal~~,~~ ~~particularly, the corrosion of the cathode side separator causes problems~~. ~~That is, from study of the inventors, I~~it is ~~found~~ often the case ~~out~~ that positive corrosion prevention is more effective than prevention of simple contact resistance for improving the performance of the fuel cell.

~~[0040]~~[0034] ~~Therefore~~Accordingly, the principles of the present invention ~~suggests~~ are directed towards preventing corrosion of the side separators for improving performance of the fuel cell. ~~Though~~ Although any methods that can effectively prevent

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corrosion of the cathode side separator ~~are~~ is applicable, an example method will be ~~in~~ described in the following example embodiment ~~is simple and effective~~. Note that the example embodiment to follow is for illustration only and is not meant to limit the scope of other embodiments disclosed herein or to limit the scope of the appended claims. As mentioned previously, it will be appreciated that other methods that prevent corrosion of the side separators are also contemplated.

~~[0041]~~[0035] Referring again to FIG. 7, ~~there is~~ a medium layer 300 is shown between the cathode side separator 40 and the cathode ~~40~~ 20 configured for prevention of corrosion of the cathode side separator 40. ~~Though~~ Although the medium layer 300 may be provided separately, it is preferable in some embodiments that the medium layer 300 ~~is~~ be a coated layer of a material selected from materials having ionization tendencies similar to the cathode 20. Having similar ionization tendencies between medium material 300 and cathode 20 helps to prevent ~~Because it is found out from the study of the inventors that a principal cause of~~ the corrosion at the cathode side separator 40 that may be ~~is~~ caused by a voltage difference ~~coming from~~due to ~~a~~ differences of ~~the~~ ionization tendencies of the cathode 20 and the cathode side separator 40.

[0036] ~~In the meantime, it is required that~~As illustrated in FIG 7, the coated layer 300 on the cathode side separator 40 ~~is at least on~~may be applied to a contact surface 302 ~~to~~ of the cathode 20, ~~and~~ a bottom surface 304 of the passages 46, and ~~preferably on~~ a wall surface 306 of the passages 46.

~~[0043]~~[0037] ~~In the meantime, in general, since~~Since the cathode 20 often includes a Pt catalyst, the coated layer 300 may be formed of Pt, gold, copper, nickel, and the like, without limitation, having an ionization tendency the same or similar to Pt., ~~and it is~~In some embodiments it is preferable that the coated layer 300 ~~is~~ be formed of gold, ~~taking~~

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due to production costs~~,~~ ~~and~~ ,production processes and the like~~, and the like into account~~.

~~[0044]~~[0038] ~~On the other hand~~In addition, ~~the~~ corrosion may also take place at the anode side separator 50. ~~Therefore~~Accordingly, ~~it is preferable that~~ a medium layer (not shown), for ~~an~~ example~~,~~ similar or the same as the coated layer 300, ~~is~~ may also be applied to ~~formed on~~ the anode side separator 50 for prevention of corrosion of the anode side separator 50. Of course, in ~~this instance too~~such embodiment, it is also preferable that the coated layer is formed of a material ~~selected from materials~~ that shows little or no voltage differences from the anode 30.

~~[0034]~~Referring now to FIG. 8, an ~~as~~ illustration of a graph showing a comparison of the electric generating capacity of the fuel cells of the present invention and the prior art is shown~~a result of experiment of the inventors.~~; ~~in a~~In this case ~~of~~, a fuel cell ~~with~~has ~~the~~ a cathode side separator 40 ~~including~~ that includes Pt~~,~~. The plot of FIG 8 shows that ~~it is verified that the~~when the fuel cell, as in the present invention, ~~with a~~ further includes a gold coated layer (i.e., medium layer 300), the fuel cell ~~can improve~~shows approx. 50% ~~of~~ improvement in electric generating performance as compared to when the fuel cell, as in the prior art, does not include ~~the related art fuel cell without~~ the coated layer 300, if other conditions are the same. Since results of experiments for various kinds of fuel cells show similar trends, only one result of the experiment is shown in FIG. 8 for convenience.

~~[0039]~~ ~~Moreover, as shown in FIG. 9, the principle of the present invention is applicable to other forms of fuel cells.~~ Similar performance results may also be seen in FIG 9.

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[0040] ~~For an example, as shown in~~Turning to FIG. 10~~,~~, an alternative embodiment of a fuel cell is illustrated. As illustrated, there may be a porous supporting member 100, for ~~an~~ example, a mesh member, between the cathode 20 and the cathode side separator 40. The supporting member 100 is also susceptible to ~~corro~~corrosion. To help prevent such corrosion~~ded, and it is preferable that such corrosion is prevented. That is~~, a ~~,~~gold plating may be applied to~~on~~ the supporting member 100 to reduces the inner resistance, ~~and~~ which ~~shows~~ allows a performance improvement as explained above. ~~Of course~~In some embodiments, ~~it is more effective~~the performance improvements are greater if the cathode side separator 40 is coated with gold.

[0036]In ~~the meantime~~addition, there ~~can~~ may also be an anode supporting member 80 between the anode 30, and the anode side separator 50. Supporting member 80 may also be susceptible to corrosion. Accordingly, ~~,~~ ~~and~~ the same principles of corrosion prevention described in relation to supporting member 100 ~~is~~ are applicable to the anode supporting member 80. Of course, the principles of above embodiments ~~is~~ are not limited to a fuel cell of the BFC type, but ~~is~~ are applicable to other fuel cells, too.

~~[0049]Industrial Applicability~~

[0050]**[0041]** The effective prevention of corrosion at the cathode side separator and/or the anode side separator ~~permits~~ helps to reduce an inner resistance of the fuel cell ~~,~~to improve electric generating performance~~,~~ and capacity~~, at the end~~.

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CLAIMS

What is claimed is:

1. A fuel cell comprising:

electrolyte;

an anode and a cathode at opposite sides of the electrolyte;

an anode side separator and a cathode side separator at outer sides of the anode and the cathode, respectively; and

a medium layer between the cathode and the cathode side separator for prevention of corrosion of the cathode side separator.

2. The fuel cell as claimed in claim 1, wherein the medium layer is a coated layer on the cathode.

3. The fuel cell as claimed in claim 2, wherein the coated layer is formed of a material selected from materials having ionization tendencies similar to the cathode.

4. The fuel cell as claimed in claim 2 or 3, wherein the cathode includes a Pt catalyst, and the medium layer is formed of gold.

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5. The fuel cell as claimed in claim 1 or 2, further comprising a medium layer between the anode and the anode side separator for prevention of corrosion of the anode side separator.

6. A fuel cell comprising:

electrolyte;

an anode and a cathode at opposite sides of the electrolyte;

an anode side separator at an outer side of the anode;

a cathode side separator at an outer side of the cathode;

a porous supporting member between the cathode and the cathode side separator for supporting the cathode; and

a supporting member medium layer between the cathode and the porous supporting member for prevention of corrosion of the porous supporting member.

7. The fuel cell as claimed in claim 6, wherein the supporting member medium layer is a coated layer on the supporting member.

8. The fuel cell as claimed in claim 7, wherein the coated layer is formed of a material selected from materials having ionization tendencies similar to the cathode.

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9. The fuel cell as claimed in claim 6, further comprising a medium layer between the cathode side separator and the porous supporting member for prevention of corrosion of the cathode side separator.

10. The fuel cell as claimed in one of claims 6 ~ 9, wherein the cathode includes a Pt catalyst, and the medium layer is formed of gold.

11. The fuel cell as claimed in one of claims 6 ~ 9, further comprising:

a porous supporting member between the anode and the anode side separator for supporting the anode; and

a supporting member medium layer between the anode and the porous supporting member for prevention of corrosion of the porous supporting member.

12. A fuel cell comprising:

electrolyte;

an anode and a cathode at opposite sides of the electrolyte;

an anode side separator and a cathode side separator at outer sides of the anode and the cathode, respectively; and

a medium layer between the anode and the anode side separator for prevention of corrosion of the anode side separator.

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ABSTRACT

A f~~F~~uel cell including an electrolyte, an anode and a cathode at opposite sides of the electrolyte, an anode side separator and a cathode side separator at outer sides of the anode and the cathode respectively, and a medium layer between the cathode and the cathode side separator configured to at least partially prevent ~~for prevention of~~ corrosion of the cathode side separator, thereby improving a performance of an electric generating performance of the fuel cell.

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